RANGER VII

A SPECIAL REPORT

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RANGER VII

A SPECIAL REPORT

August 5, 1964

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

JET PROPULSION LABORATORY
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Figure 1.—Atlas-Agena launch vehicle lifts Ranger VII off Cape Kennedy pad at 12:50 p.m. (EDT), July 28, 1964.

"THIS HISTORIC EXTENSION OF MAN'S KNOWLEDGE . . ."

At 25 minutes and 49 seconds after 9, EDT, the morning of July 31, 1964—precisely the time calculated—the United States' spacecraft, Ranger VII, impacted the moon.

In its 68½-hour voyage to the moon, the Ranger's performance was so remarkably "nominal," as scientists and engineers of the space agency state it, that they now describe this feat as "a textbook exercise," meaning everything functioned as planned.

To a large degree, the spacecraft, especially its camera system, functioned beyond the expectations of the experimenters. They knew when Ranger VII was launched from Cape Kennedy 3 days earlier, that the shutters in the 6 television cameras were expected to click some 4,000 times. From this they hoped for some 2,000 usable photographs of the lunar surface. They would have settled for less. But Ranger yielded 4,316 photographs of such high resolution that Dr. Gerard P. Kuiper, University of Arizona, one of the principal experimenters, stated conservatively that the data returned to earth provided the scientific community with some 3 years of work before a thorough evaluation can be made. It is now apparent that within 3 months of the impact they can make public their preliminary findings.

The photographic system performed to the limit of its design capability, delivering pictures described as having clarity and definition a thousand times better than those available from earth-based telescopic cameras. Topographic features less than 3 feet across are discernible, objects described by one science writer as "the size of a bushel basket."

This achievement—near perfection from launch to impact—was immediately hailed from all corners of the world in such superlatives as "stupendous" and "spectacular." President Johnson proclaimed, "We are proud of this historic extension of man's knowledge." He was confirming the acclamations of scientists who were now declaring this as the greatest single advance in astronomy since Galileo's investigation of natural laws four centuries earlier. How great an achievement remains to be determined.

"We know this morning," President Johnson said from the White House on August 1, 1964, "that the United States achieved fully the leadership we sought for free men." He was making no claim that this was an American triumph alone. Rather, he recognized it for what it was, ". . . a victory for peaceful civilian international cooperation in this hour of frustration when so many people are getting upset at some minor disappointments."

The Ranger program was not itself without its disappointments and frustrations. The Ranger team had known failure, but never faltered in its determination to overcome the great and seemingly insurmountable problems which had to be solved before the photographic mission to the moon could be successfully accomplished. Scientists and engineers translated every frustration into determination and each failure into a lesson, all applied to the textbook written for the Ranger VII success.

It seemed now a long time since the National Aeronautics and Space Administration had directed the Jet Propulsion Laboratory on December 21, 1959, to conduct studies of an automated spacecraft design and mission to "acquire and transmit a number of images of the lunar surface." No one then imagined that this number today would be 4,316 in almost 17 minutes of picture taking. But at that time eminent scientists throughout the world were agreed that even in the absence of a manned lunar landing program, unmanned exploration of the moon would be a sound enterprise justified on its own merits, not as a reconnaissance flight for future manned exploration of the Moon but for the scientific information it would yield. The prophecies were proven correct.

It was without question one of the most complicated scientific and engineering feats attempted by man. There were literally thousands of things which could have gone wrong and doomed the flight. But everything worked and worked as expected when expected.

This success was a plural thing. Best estimates place the number at 10,000 people in government, industry, universities, and the scientific community who participated. When the President stated it was "not an American triumph alone," he was thanking the many countries throughout the world for their tracking stations. The cost of the project is an estimated $260 million which includes two Ranger shots to go. Ranger VII is estimated to have cost some $28 million including the Atlas-Agena launch vehicle which boosted the spacecraft into space.

The benefits, too, will be plural. Scientists the world over will have access to the data the Ranger VII photography is yielding. Already there is confirmation that the basic assumptions made in the manned lunar landing program are sound. Dr. Homer Newell told the President, "These data have provided a reassurance that the range, design range, used in designing the lunar excursion module, is sufficient to take into account the difficulties of landing that will be encountered." Scientists know now that Ranger VII's exploration gives "credence to some theories and discounts other theories."

The public confidence, shaken 7 years ago by Sputniks I and II, is also served by this achievement. Dr. Newell assured the President in summarizing the Ranger report, "This country does not need to hang its head. . . ."

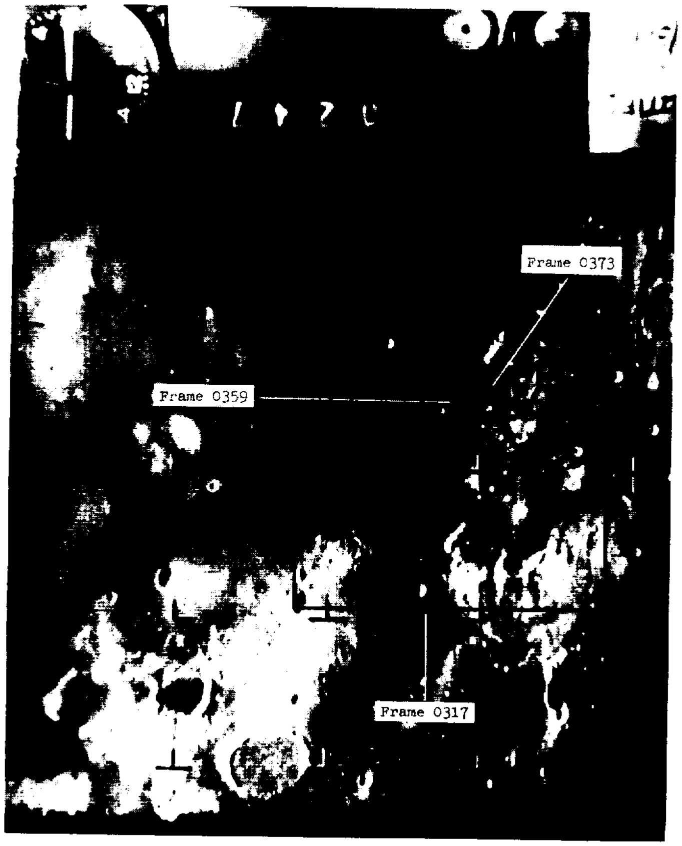

Figure 2.—Frame 247.

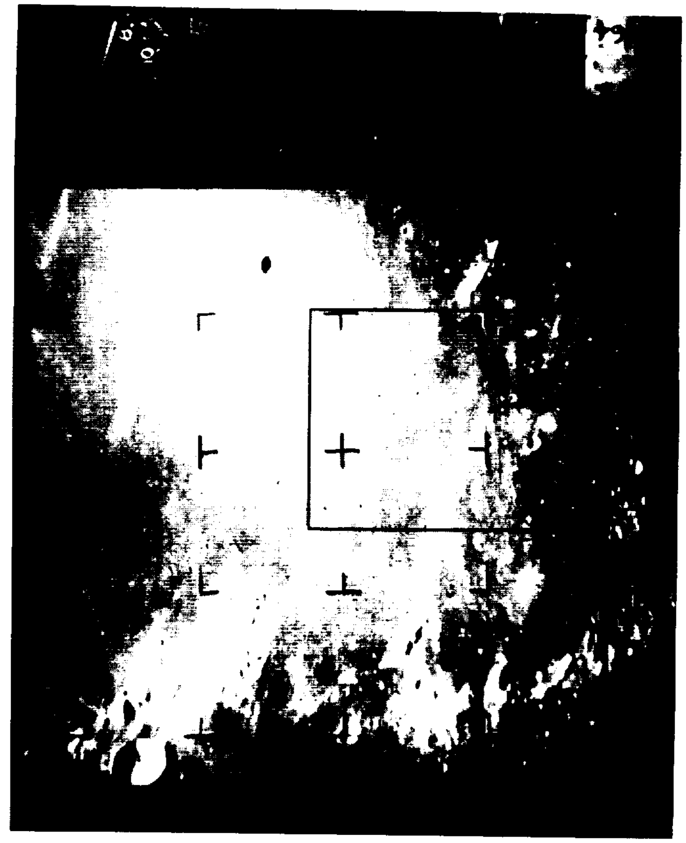

Figure 3.—Frame 317.

Figure 4.—Frame 359.

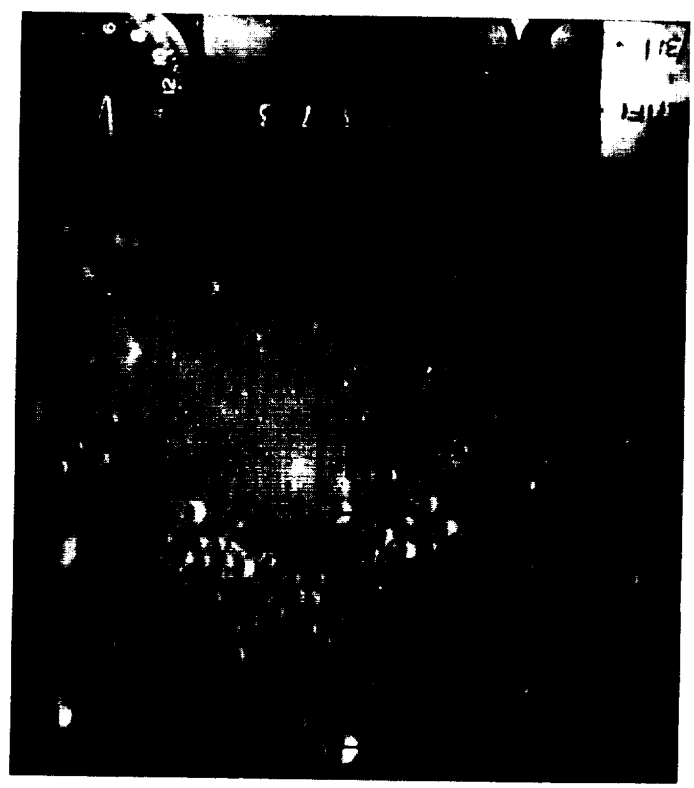

Figure 5.—Frame 373.

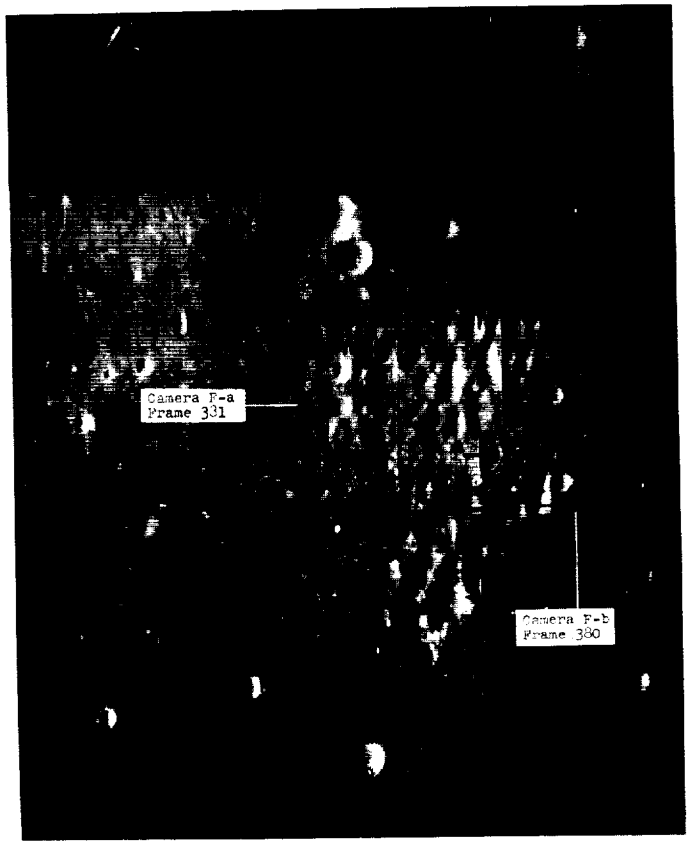

Figure 6.—Frame 379.

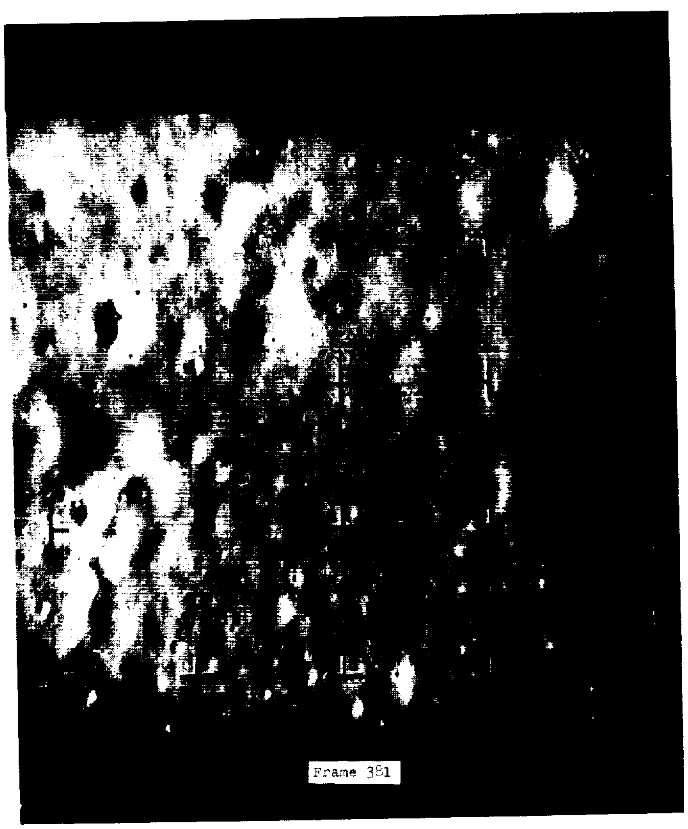

Figure 7.—Frame 381.

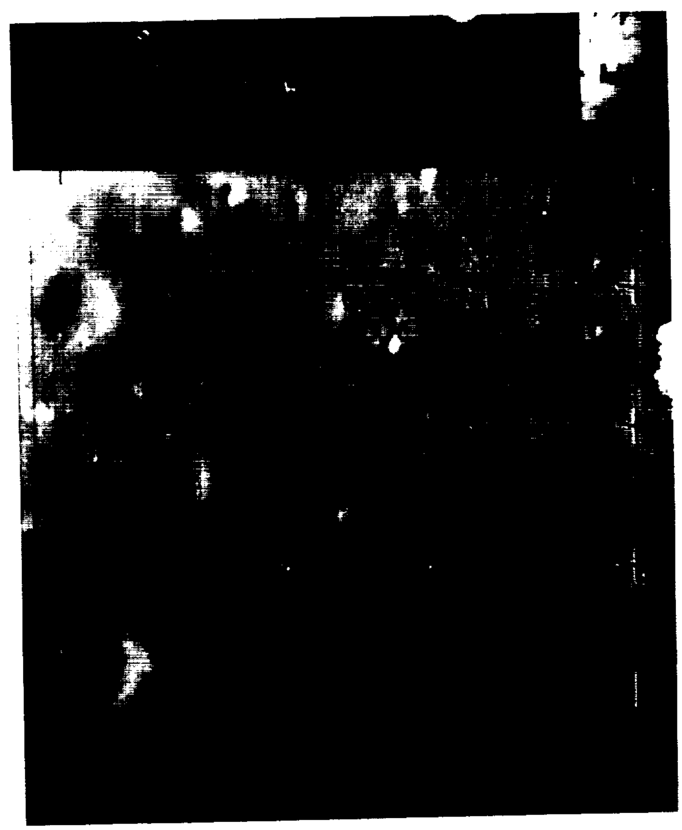

Figure 8.—Frame 380.

RANGER PHOTOGRAPHIC DETAILS

The following series of photographs shows the dramatic increase of lunar detail Ranger VII provides over earth-based telescopes.

The first Ranger photograph, frame 247 (fig. 2), shows details of the lunar surface in about the same resolution as photographs taken by earth-based observatories. This and the rest of the pictures in this series were taken by one of Ranger's two full-scan cameras—designated the F–a camera—with a 25 mm, f/1 lens and a field of view of 25°.

In frame 247, note the twin peaks in the center of the mare or bay which extends northwest from the Mare Nubium or Sea of Clouds. Ranger VII photographed that area before impact just south of the twin peaks.

The series of photographs taken by Ranger VII illustrates the nesting technique used by Ranger VII, in that each photograph shows in greater detail an area within the preceding picture. The area covered by the next photograph is outlined in black on each picture. In frame 247, several succeeding photographs are outlined.

The F–a camera took 191 pictures. Ones prior to frame 247 show the lunar surface with less detail than do earth telescopes. The F–a camera took a picture once each 2.56 seconds, the time between the taking of the last two pictures in the series. The first two were taken about 3 minutes apart.

Almost directly below and slightly to the right of the peaks are two small, well-defined craters side by side. They appear with double the resolution in frame 317 (fig. 3), with the left one partially hidden by the grid mark second from the right in the second row from the top. The square drawn on frame 247 is the area covered by frame 317, and so on through this series.

In the next photograph, frame 359 (fig. 4) taken from an altitude of 85 miles, resolution has again doubled so that a cluster of secondary craters in the center of the picture becomes distinct for the first time. The crater cluster is shown with almost three times the resolution in frame 373 (fig. 5) taken about half a minute later from a 34-mile altitude.

Frame 379 (fig. 6), the next-to-last F–a camera picture, was taken 15 seconds later from an altitude of 12 miles. Its resolution is more than tripled over the previous frame. In this picture, designated by the two outlined squares, are the final pictures taken by the two full-scan cameras.

The larger square on the left is shown in greater resolution in the unnumbered frame which was the last (191st) picture taken by the F–a 25-mm, f/1 camera. Resolution has again tripled. The smaller square is shown in more detail as frame 380 (fig. 8) which was taken by the F–b camera with a 75-mm, f/2 lens.

The unnumbered frame—the 381st (fig. 7) to be recorded by the full-scan cameras—was taken only 2.3 seconds before impact from an altitude of 3 miles.

FLIGHT CHRONOLOGY

At 12:50:08 p.m., July 28, 1964, just 8 seconds off the earliest scheduled launchtime, Ranger VII left the launching pad at Cape Kennedy, Fla., on its historic 243,665-mile photographic mission to the moon.

The Atlas-Agena launch vehicle performed flawlessly, with the second stage, Agena, firing until its velocity reached approximately 17,500 miles per hour. At this point it was in orbit about 115 miles above the earth and coasted for almost a half hour when the engine was again ignited. Second ignition increased the vehicle's velocity to about 24,525 miles per hour, putting it into a previously selected moon corridor about 10 miles in diameter and within 4 miles per hour of the velocity necessary for this maneuver. At the same time, the increased speed was necessary to escape the gravitational pull of earth.

Because the launch was so accurate, there was now no doubt that the moon would be hit. The only problem remaining was to select the precise target area from a number of predetermined impact areas. The planned midcourse maneuver was designed to carry out this function.

July 29, between 4:54 and 4:58 a.m., EDT, commands, for later execution, were sent to and stored in the spacecraft from Goldstone, Calif., a station in the deep space network. These commands would alter Ranger VII's course and place it in the precise trajectory for impact on the now definitely selected primary target area on the light side of the moon.

At 5:40 a.m., the spacecraft's transmitter was ordered to switch from a directional antenna at the base of the craft to the omnidirectional antenna on top. With this order the directional antenna was moved out of the path of the midcourse maneuver motor exhaust.

At 6 a.m., a command was given to Ranger VII to execute the previously stored instructions. Forty-four seconds later, pitch-and-roll maneuvers began to orient the spacecraft. The roll program continued from 6:00:44 to 6:01:08. Pitch began at 6:10:07 and continued to 6:16:41 a.m.

From 6:27:09 to 6:27:59 a.m., the midcourse motor fired, giving the velocity required to alter the flight path and time of flight.

At 6:28 a.m. the spacecraft began reorientation by reacquiring the sun. This was completed at 6:36 a.m. At 6:58 earth reacquisition began and was obtained almost immediately.

Ranger VII was now definitely set on course to 11° south latitude and 21° west longitude.

The target area was an ellipse 300 by 50 miles. This would grow smaller as the spacecraft neared its target. Time of impact was computed after the midcourse maneuver and predicted for 9:25 a.m., EDT, July 31, 1964.

The morning of July 31 at 9:08:39 a.m., EDT, the full scan camera system of Ranger VII took the first pictures of the lunar surface. At 9:12:08 the partial scan cameras began taking pictures.

These were transmitted back to the receiving station at Goldstone where they were recorded on magnetic tape and, by kinescope of the video pictures being received, on 35-mm film.

Lunar pictures continued to be transmitted, 4,316 excellent quality photos, until Ranger VII, traveling 5,850 miles per hour, plunged into the surface of the moon at 9:25:49 a.m., EDT. The point of impact was about 7 to 10 miles off the predicted impact point. The precise location was 10.7° south latitude, 20.7° west longitude.

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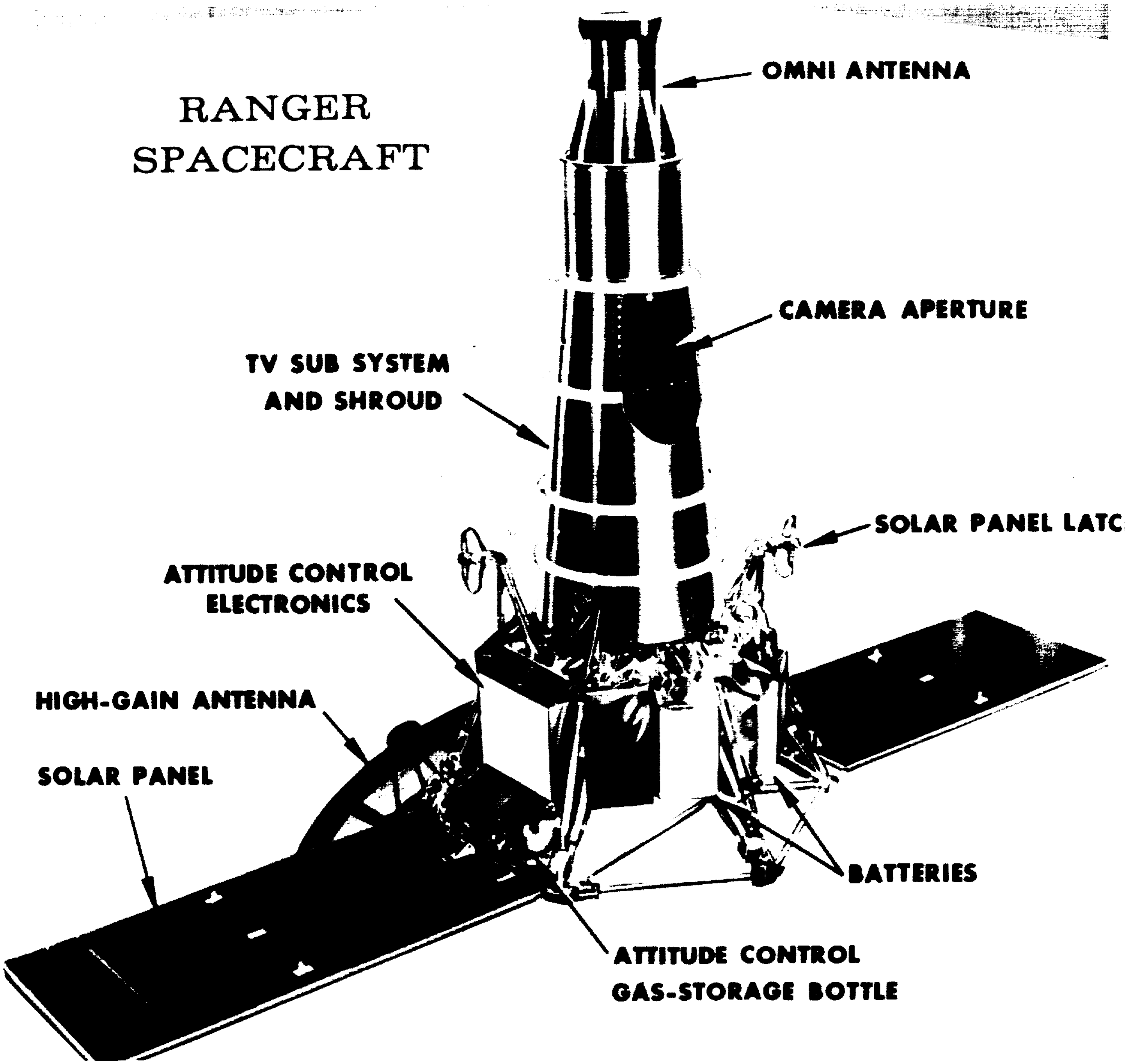

RANGER
SPACECRAFT
OMNI ANTENNA
CAMERA APERTURE
TV SUB SYSTEM
AND SHROUD
SOLAR PANEL LATCH
ATTITUDE CONTROL
ELECTRONICS
HIGH-GAIN ANTENNA
SOLAR PANEL
BATTERIES
ATTITUDE CONTROL
GAS-STORAGE BOTTLE

Figure 9

MANDATE FOR LUNAR EXPLORATION

The National Space Act of 1958 established the National Aeronautics and Space Administration and assigned to the civilian agency the planning and conduct of those activities in space "devoted to peaceful purposes for the benefit of all mankind."

The new agency was instructed by Congress to arrange for full participation of the worldwide scientific community and to provide the "widest practical and appropriate dissemination of information concerning its activities and results thereof."

One of the first formal programs begun by NASA to carry out this congressional mandate was the lunar and planetary exploration program. The Moon and the two nearest planets, Venus and Mars, were selected as the most reasonable objects for initial exploration.

The program for unmanned lunar exploration assumed a special importance on May 25, 1961, when President Kennedy announced the national objective of landing men on the moon in this decade and safely returning them to earth—Project Apollo.

A letter dated December 21, 1959, launched the U.S. effort that reached a historic climax July 31 when the Ranger VII spacecraft zoomed into the moon while sending 4,316 closeup television pictures of the lunar surface.

The letter was written by Dr. Abe Silverstein, then Director of the National Aeronautics and Space Administration's Office of Space Flight Programs. Dr. Silverstein, now Director of NASA's Lewis Research Center, Cleveland, Ohio, was on hand at Cape Kennedy July 28 to see the Atlas-Agena launch vehicle send Ranger VII on its way.

Recipient of the 1959 letter was Dr. William Pickering, Director of Jet Propulsion Laboratory of the California Institute of Technology. The laboratory is in Pasadena, Calif.

Dr. Silverstein requested JPL to conduct studies of an automated spacecraft design and mission to "acquire and transmit a number of images of the lunar surface."

Early in 1960, under a contract with NASA, JPL was assigned management of the project which has since called into play the combined talents and capabilities of scientists and engineers in industry, universities, and government.

Actually, there are three flight projects in NASA's lunar program—Ranger, Surveyor, and Lunar Orbiter.

Primary objective of the Ranger program, demonstrated by Ranger VII, is to obtain closeup television pictures of the lunar surface during the last few minutes before the spacecraft crashes into the surface.

Surveyor spacecraft will make soft landings, televise the nearby lunar terrain, take samples of the lunar surface material and report back to earth the chemical and physical properties of the material inspected by its instruments.

The Lunar Orbiter will go into orbit around the moon and take comprehensive and detailed photographs of the lunar surface from as close as 22 miles. These will aid in selecting touchdown areas for the Apollo manned lunar-landing program.

However, the Orbiter also will make scientific measurements of the moon and its environs that will assist in determining the mass distribution of the moon.

Such information is vital to any discussion of the origin of the moon-earth system and to resolve conflicting theories on the origin of the solar system.

Photo reconnaissance by the Orbiter will aid in evaluating and correlating data obtained by Surveyor spacecraft, will screen out undesirable sites for landing other Surveyors, and will team with Surveyors to verify suitable landing sites for the two-man Apollo Lunar Excursion Module.

The first two Ranger vehicles, designated Block I, were not intended to land on the moon. They were used to check out and test the major subsystems of both the launch vehicle and the spacecraft in eccentric earth orbits.

The next three Rangers in Block II were aimed at the moon. One spacecraft impacted the backside of the moon, and the other two flew by at 21,000 miles and 450 miles. However, none of these fulfilled mission objectives due to one launch vehicle failure and some spacecraft malfunctions.

Ranger VI, the first of four Block III spacecraft which confined scientific experiments to the six-camera television system, performed almost flawlessly until minutes before impact when, to the great disappointment of all concerned, the television cameras failed to operate.

The next two Rangers are scheduled for launch early next year. Designated Ranger-C and Ranger-D, they will be guided to areas of the moon that can be expected to show topography different from that in the Ranger VII aiming area. No other Rangers are planned.

At briefings following the Ranger VII success, the Ranger experimenters indicated future target areas might include an aiming point inside one of the large craters such as Copernicus.

The first U.S. on-the-spot exploration of the moon will be by two NASA astronauts in the Apollo project.

After achieving a parking orbit around the moon, two of the three astronauts in the Apollo Command Module will enter the Lunar Excursion Module (LEM). The LEM will separate from the Command Module and descend to make a soft landing on the moon.

On the surface, one of the astronauts will step out of the LEM and explore the immediate vicinity. The astronauts will return in the LEM to the lunar orbit, dock with the Command Module, and leave the LEM in a lunar orbit. Scientific instruments may be left on the moon to make additional experiments.

Venus was the target of the first dramatic flight mission success of NASA's lunar and planetary exploration program.

After a 109-day flight, NASA's Mariner II spacecraft inspected Venus from a distance of 21,648 miles on December 14, 1962. The fly-by mission probed the planet with electronic sensors and sent back to earth its findings concerning the nature of interplanetary space and of Venus itself.

America's first attempt to make closeup photographs of another planet is scheduled for the last 3 months of 1964 when NASA launches two Mariner spacecraft on a mission to gather data from the vicinity of Mars.

Unlike Ranger, the Mariner Mars spacecraft are not designed to hit the planet. Where the Ranger spacecraft took about 68 hours to reach its destination, the Mariner Mars vehicles will be en route for about 8 months before they encounter Mars.

In addition to pictures, the Mariners will sample and report magnetic fields, micrometeoroid data, radiation and solar effects in the vicinity of Mars, and atmospheric and surface characteristics of the planet itself.

An important scientific objective of the Mariner Mars mission is to determine the possibilities for life, in plant or animal form, to exist on Mars.

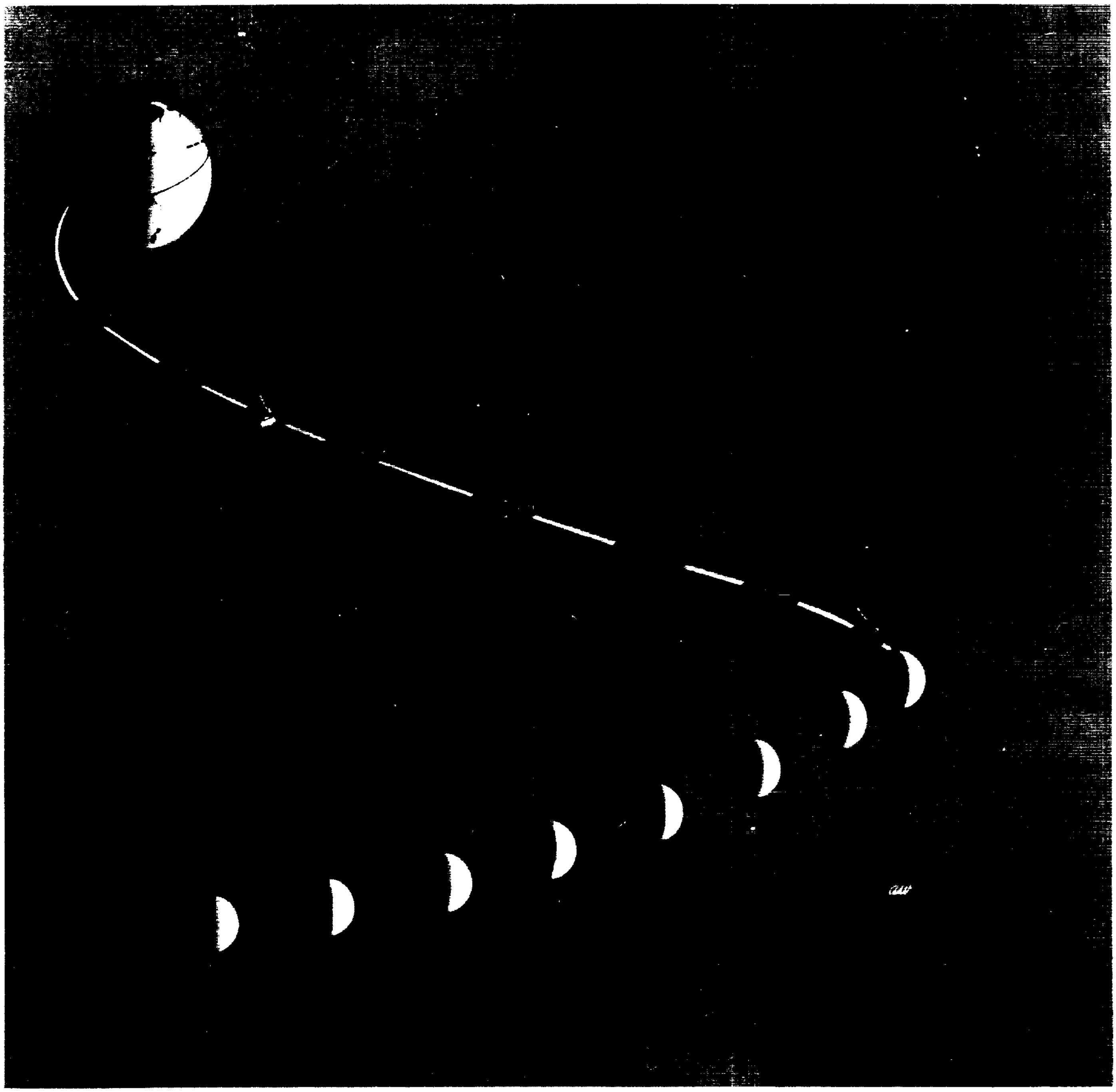

Figure 10

RANGER SPACECRAFT

The Ranger spacecraft was designed and built by the Jet Propulsion Laboratory. Industrial contractors provided a number of subsystems and components.

Ranger continued the design concept used in earlier Rangers, and in the Mariner II Venus fly-by spacecraft, of a basic unit capable of carrying varying payloads. This unit, or bus, provided power, communication, attitude control, command functions, trajectory correction, and a stabilized platform for mounting scientific instruments.

The bus was a hexagon framework constructed of aluminum and magnesium tubing and structural members. Electronics cases were attached to the six sides and a high-gain, dish-shaped antenna is hinged to the bottom. The midcourse motor was set inside the hexagonal structure with the rocket nozzle facing down. The bus also included a hat-shaped, omnidirectional antenna which was mounted at the peak of the conical television system structure.

Ranger VII was 5 feet in diameter at the base of the hexagon and 8¼ feet high. With the solar panels extended and the high-gain antenna deployed, the spacecraft measured 15 feet across and 10¼ feet high.

Two solar panels, hinged to the base of the hexagon, were folded like butterfly wings during launch. The panels provided 24.4 square feet of solar cell area and delivered 200 watts of raw power to the spacecraft. There were 4,896 solar cells in each panel.

Two silver-zinc batteries provided power for the bus during launch, prior to opening the solar panels, and during the midcourse and terminal maneuvers when the panels were not pointed to the sun. The batteries had a capacity for 9 hours of spacecraft operation and provided 26.5 volts each. A single battery could provide power for launch, midcourse, and terminal maneuvers.

The TV system carried two batteries capable of operating cameras for 1 hour.

The six cases which girdled the spacecraft contained the following: case 1, central computer and sequencer and command subsystem; case 2, radio receiver and transmitter; case 3, data encoder (telemetry); case 4, attitude control (command switching and logic, gyros, autopilot); case 5, spacecraft launch and maneuver battery; case 6, power booster regulator, power switching logic, and squib firing assembly; case 6B, second spacecraft launch and maneuver battery.

TRAJECTORY LIMITATIONS ON RANGER PHOTOGRAPHIC MISSIONS

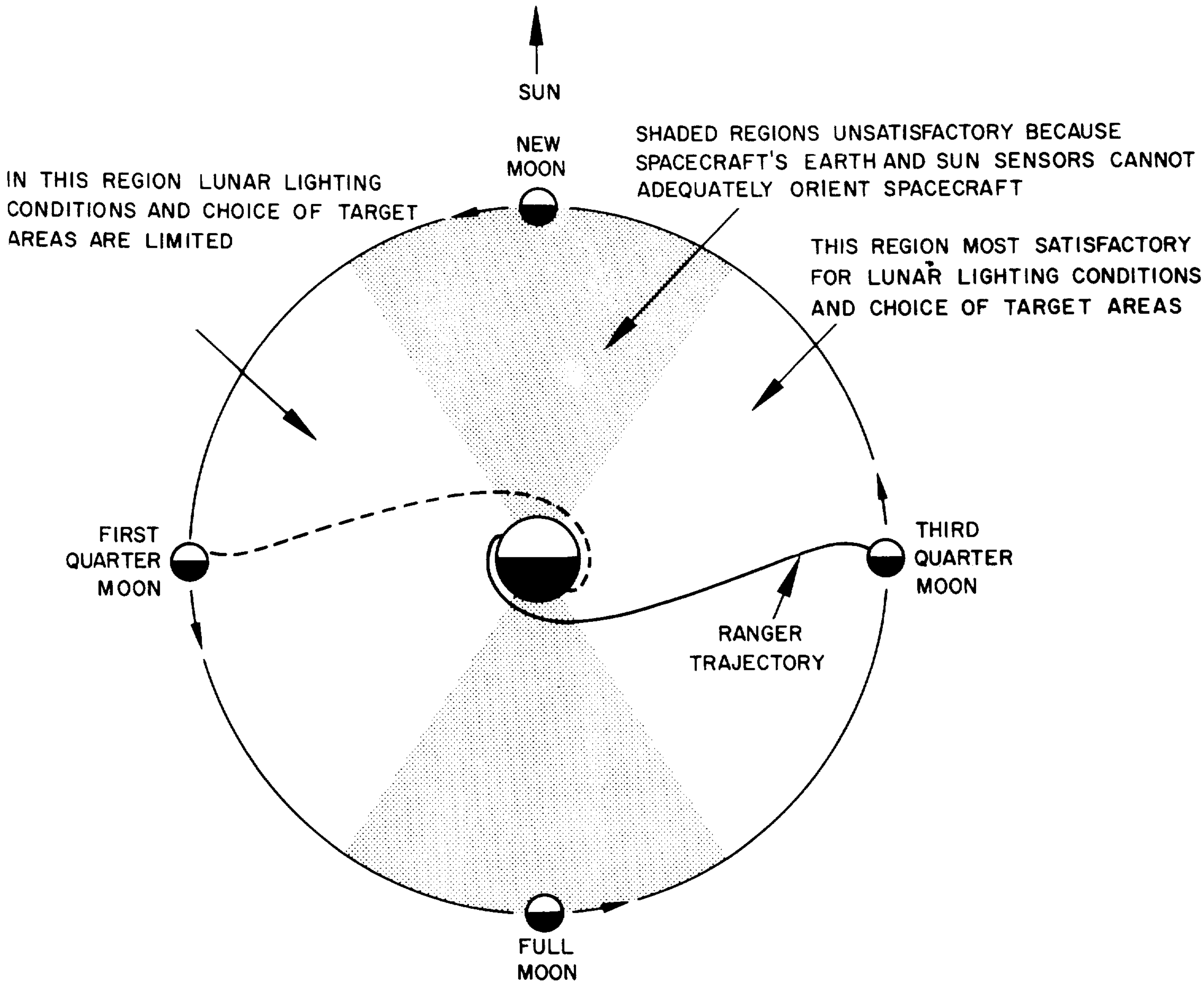

Figure 11

RANGER FACT SHEET

LAUNCH VEHICLE — Atlas-Agena B.

DIMENSIONS LAUNCH VEHICLE

Total height, with Ranger spacecraft plus shroud	100 feet plus.
Atlas	66 feet.
Agena B	22 feet.
Ranger with shroud	12 feet.

DIMENSIONS RANGER

In launch position:	
Diameter	5 feet.
Height	8.25 feet.
In cruise position:	
Span	15 feet.
Height	10.25 feet.

WEIGHT RANGER

	Pounds
Structure	91. 15
Communications	38. 71
Attitude control and autopilot	59. 05
Data encoder	20. 10
Central computer and sequencer	9. 61
Propulsion	45. 22
Power (solar panels, launch backup battery, etc.)	123. 30
Miscellaneous equipment	37. 85
Ranger bus total	424. 99

TV SUBSYSTEM

Cameras	37. 95
Camera electronics	48. 68
Video combiner	3. 17
Sequencer	13. 92
Batteries	86. 24
Transmitters and associated equipment	70. 24
Structure and miscellaneous	121. 30
TV subsystem total	381. 50
GROSS WEIGHT	806.49

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RANGER LAUNCH TO MOON

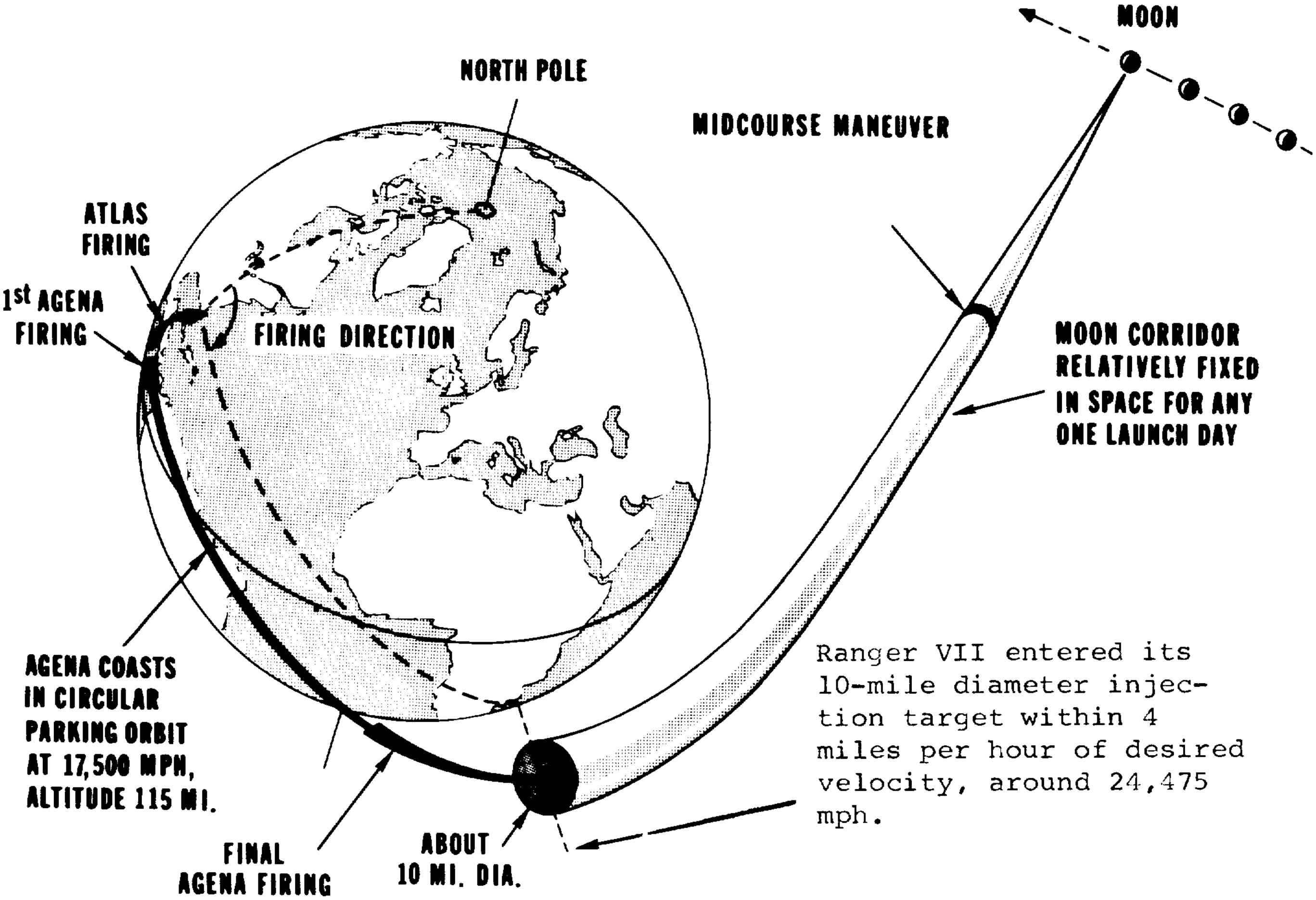

Figure 12

LAUNCH VEHICLE

Ranger VII was launched by an Atlas D booster and an Agena B second stage combination. The Atlas rose vertically and pitched over to an azimuth angle determined by the launch time. The ground guidance system sent commands by radio which cut off and jettisoned the Atlas' two booster engines, and shortly afterward cut off its sustainer engine. After a vernier adjustment of velocity, the Atlas and Agena separated.

The Agena engine fired until orbital speed of approximately 17,450 miles per hour was reached. The engine cut off and the Agena and the Ranger coasted over the Atlantic in a parking orbit at an altitude of 115 statute miles. The Agena engine reignited at the predetermined end of this coast period and burned until the injection velocity of approximately 24,500 miles per hour was reached. Shortly after cutoff, the Agena separated from the Ranger.

The NASA Lewis Research Center, Cleveland, Ohio, has technical direction of the Agena program. Seymour C. Himmel is Agena Project Manager at Lewis. George M. Bode is Ranger Project Engineer.

Lewis purchased the Agena B vehicle and its equipment for Ranger VII directly from Lockheed; the Atlas was purchased through the Space Systems Division of the U.S. Air Force Systems Command.

Launch countdown began approximately 7 hours before the estimated liftoff.

Liftoff Weight

Atlas-Agena B/Ranger—About 277,000 pounds.

Liftoff Height

Atlas-Agena B/Ranger—Approximately 104 feet.
(including adapters).

Atlas D Booster

Propellants	Liquid oxygen and RP–1, a kerosene-type fuel.
Thrust	Approximately 370,000 pounds at sea level.
Height	Approximately 66 feet.
Liftoff Weight	Approximately 260,000 pounds (fueled).
Propulsion	Two booster engines, 1 sustainer engine and 2 vernier attitude and roll control engines (built by Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif.).
Speed	Approximately 12,600 miles per hour (at apogee for Ranger flight).
Guidance	General Electric radio command guidance equipment; Burroughs ground guidance computer.
Contractor	General Dynamics/Astronautics, San Diego, Calif.

Agena B Second Stage

Propellants	Inhibited red fuming nitric acid (IRFNA) and unsymmetrical dimethylhydrazine (UDMH).
Thrust	16,000 pounds in space.
Height	21 feet.
Weight	16,000 pounds (fueled).
Propulsion	One engine (built by Bell Aerosystems Co., Buffalo, N.Y.).
Speed	Approximately 17,500 miles per hour after first burn.* Approximately 24,525 miles per hour at spacecraft injection.*
Guidance	A self-contained system made up of timing devices, an inertial reference system, a velocity meter, and an infrared horizon-sensing device.
Contractor	Lockheed Missiles & Space Co., Sunnyvale, Calif.

*For Ranger flight.

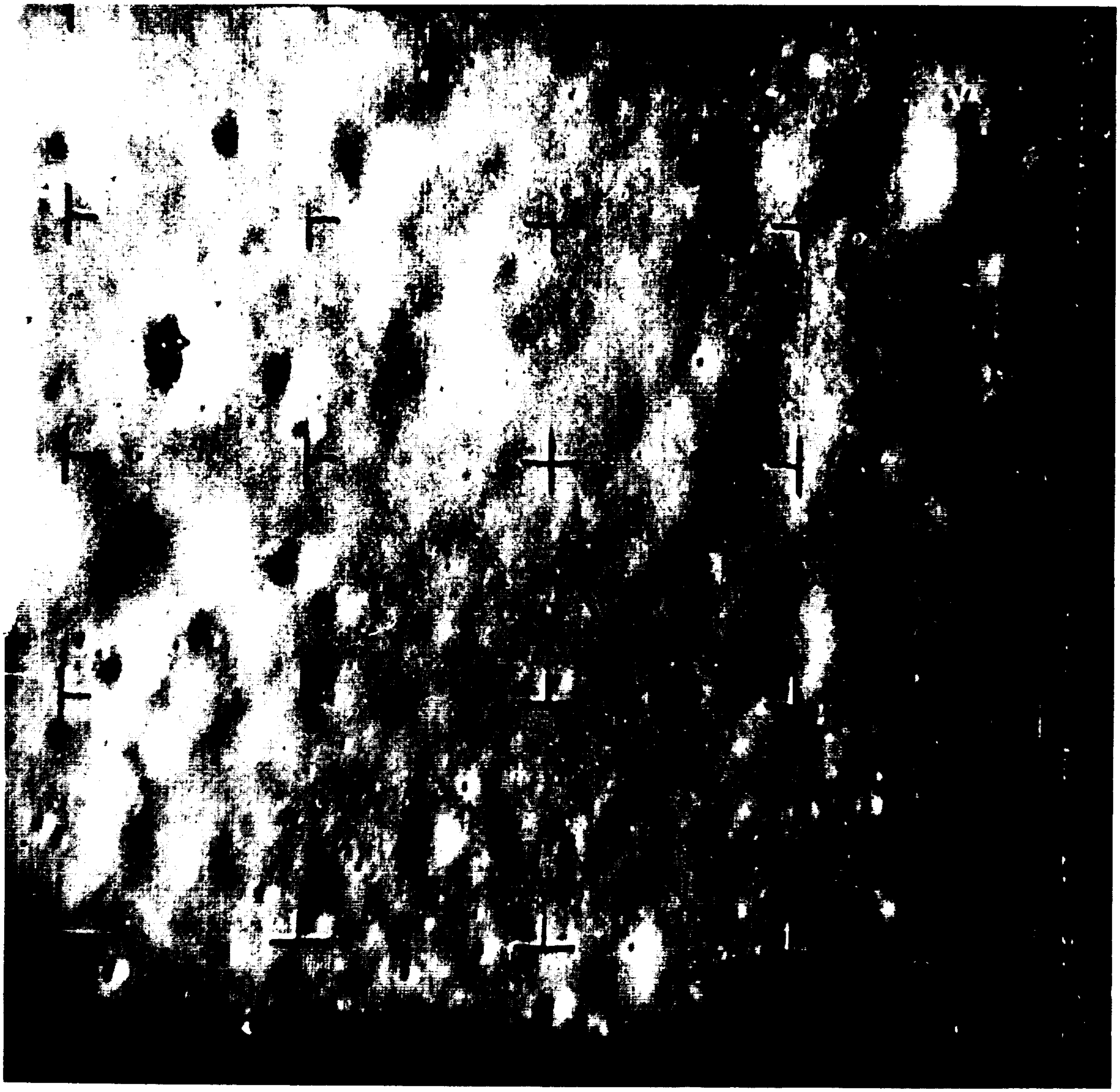

Figure 13.—Picture was taken at about 3 miles altitude and 2.3 seconds before impact of Ranger VII. Each side of area shown is about 1.66 miles. Crater, upper left, with two rock masses protruding into sunlight, is about 300 feet across.

RANGER TEAM

The National Aeronautics and Space Administration's programs for unmanned investigation of space are directed by Dr. Homer E. Newell, Associate Administrator for Space Science and Applications. Oran W. Nicks is the Director of the Lunar and Planetary Programs Division and Newton W. Cunningham is the Ranger Program Manager.

Vincent L. Johnson is the Director of OSSA's Launch Vehicle and Propulsion Programs Division, and Joseph B. Mahon is Agena Program Manager.

NASA has assigned Ranger project management to the Jet Propulsion Laboratory, Pasadena, Calif., which is operated for NASA by the California Institute of Technology. Dr. William H. Pickering is the Director of JPL and Assistant Director Robert J. Parks heads JPL's lunar and planetary projects.

H. M. Schurmeier is JPL's Ranger Project Manager. A. E. Wolfe is Spacecraft Systems Manager, P. J. Rygh is Space Flight Operations Director.

Five lunar scientists are evaluating Ranger photographs of the moon to determine characteristics of the lunar topography. Principal investigator is Dr. Gerard P. Kuiper of the Lunar and Planetary Laboratory of the University of Arizona at Tucson. Dr. Harold Urey of the University of California at La Jolla; Dr. Eugene Shoemaker of the U.S. Geological Survey at Flagstaff, Ariz.; Ewen A. Witaker of the Lunar and Planetary Laboratory of the University of Arizona; and Raymond L. Heacock of the Jet Propulsion Laboratory are coexperimenters.

Tracking and communication of Ranger VII was the responsibility of the NASA/JPL Deep Space Network. Dr. Eberhardt Rechtin is JPL's Assistant Director for Tracking and Data Acquisition, and R. K. Mallis is DSN Operations Manager.

The Goldstone DSN station is operated for JPL by the Bendix Field Engineering Corp. Walter Larkin is JPL's engineer in charge.

The Woomera, Australia, station is operated by the Weapons Research Establishment of the Australian Department of Supply represented by Dr. Frank Wood. Richard Fahnestock is JPL's resident engineer.

The Johannesburg, South Africa, station is operated by the Council for Scientific and Industrial Research directed by Dr. Frank Hewitt. Paul Jones is JPL's resident engineer.

NASA's Lewis Research Center, Cleveland, has project management for the Atlas-Agena launch vehicle. Dr. S. C. Himmel is Agena Project Manager.

Launch Vehicle Team

The Atlas, designed and built by General Dynamics/Astronautics, San Diego, Calif., was purchased through the Space Systems Division of the U.S. Air Force Systems Command. Rocketdyne Division of North American Aviation, Inc., of Canoga Park, Calif., built the propulsion system. Radio command guidance was by Defense Division of General Electric Co. and ground guidance computer by the Burroughs Corp.

The Agena B stage and its mission modifications were purchased directly by the Lewis Center from Lockheed Missiles & Space Co., Sunnyvale, Calif. Bell Aerosystems Co., Buffalo, N.Y., provided the propulsion system.

Launchings for the Lewis Center were directed by the Goddard Space Flight Center's Launch Operations at Cape Kennedy, directed by Robert H. Gray.

Thirty-seven subcontractors to the Jet Propulsion Laboratory, listed below, provided instruments and hardware for Ranger VII and other Rangers in this series. These contracts amounted to $32.5 million:

Astrodata, Inc. Anaheim, Calif.	Time Code Translators, Time Code Generators, Ground Command Read-Write and Verify Equipment.
Ampex Corp. Instrumentation Division Redwood City, Calif.	Tape Recorder for Video.
Airite Products Los Angeles, Calif.	Midcourse Motor Fuel Tanks.
Beckman Instruments, Inc. Systems Division Fullerton, Calif.	Data Monitoring Consoles for Telemetry Operational Support Equipment, Digital Measuring/Recording for Power Operational Support Equipment.
Barry Controls Glendale, Calif.	Hi-gain Antenna.
Bell Aero Systems Co. Cleveland, Ohio	Digital Accelerometer Modules.
Conax Corp. Buffalo, N.Y.	Midcourse Propulsion Explosive Valves Squibs.
Controlled Products and Electronics Huntington Park, Calif.	Structural Supports.
Dynamics Instrumentation Co. Monterey Park, Calif.	DC Amplifiers.
Electro-Mechanical Research Inc. Sarasota, Fla.	Subcarrier Discriminators for Telemetry Operational Support Equipment.
Electro-Optical Systems Pasadena, Calif.	Power Subsystem.
Electronic Memories, Inc. Los Angeles, Calif.	Magnetic Counter Modules for the CC&S.

Fargo Rubber Corp. Los Angeles, Calif.	Midcourse Propulsion Fuel Tank Bladders.
Heliotek Division Textron Electronics, Inc. Sylmar, Calif.	Solar Cells.
Instrument Machine Co. South El Monte, Calif.	Pin Pullers.
Link Division General Precision, Inc. Palo Alto, Calif.	Video Processing Film Converter.
Mincom Division Minnesota Mining & Manufacturing Los Angeles, Calif.	Tape Recorders for Ground Telemetry Equipment.
Motorola, Inc. Military Electronics Division Scottsdale, Ariz.	Spacecraft Data Encoders, Transponder, and associated Operational Support Equipment.
Nortronics A division of Northrop Corp. Palos Verdes, Calif.	Spacecraft CC&S Subsystem, Attitude Control Subsystem, and associated Operational Support Equipment.
Optical Coating Laboratory, Inc. Santa Rosa, Calif.	Solar Cell Cover Slips.
Ryan Aeronautical Co. Aerospace Division San Diego, Calif.	Solar Panels.
Radio Corp. of America Astro Electronic Division Princeton, N.J.	Lunar Impact Television Subsystem, and associated Operational Support Equipment.
Rantec Corp. Calabasas, Calif.	Directional Couplers, Diplexers, and Circulators for the RF Subsystem.
Resdel Engineering Co. Pasadena, Calif.	RF Amplifiers.
G. T. Schjeldahl Co. Northfield, Minn.	Thermo Shield.
Skarda Manufacturing El Monte, Calif.	Structural Components.
Teb Inc. El Monte, Calif.	Structural Components.
Texas Instruments, Inc. Apparatus Division Dallas, Tex.	Spacecraft Command Subsystem and Associated Operational Support Equipment.
Transonic Pacific Los Angeles, Calif.	Transducers; Voltage Controlled Oscillators.
Ace of Space, Inc. Pasadena, Calif.	Electronic Chassis.
Weber Metals & Supply Co. Paramount, Calif.	Forgings.
Brockell Manufacturing Co. Culver City, Calif.	Electronic Chassis.

Dunlap & Whitehead Manufacturing Co. Van Nuys, Calif.	Electronic Chassis.
Hodgson Manufacturing Co. La Crescenta, Calif.	Electronic Chassis.
Milbore Co. Glendale, Calif.	Electronic Chassis.
X-Cell Tool & Manufacturing Co. Hawthorne, Calif.	Electronic Chassis.
Minneapolis-Honeywell Regulator Co. Aero Division Minneapolis, Minn.	Gyroscopes.

In addition to these subcontractors, there were 1,200 other industrial firms who contributed to this series of Rangers.

Figure 14.—Photo, top right, was the last taken by one camera at about 1,000 feet above moon surface. Impact cut off transmission of photo, leaving mottled noise pattern. Area shown is about 100 by 60 feet. Other photo is last one taken by another camera from about 3,000 feet away. It shows an area about 100 feet on each side.

SOME U.S. EDITORIAL COMMENT

Washington Post—"We just think that an absolutely fantastic and flabbergasting job has been done, and we're thrilled."

Washington Star—"It would be difficult to overstate the scientific importance of the flawless flight of Ranger VII, our picture-taking mooncraft."

"Ranger VII increases lunar knowledge a thousand fold."

New York Herald Tribune—". . . it can still, in an age of scientific miracles, evoke awe."

"Ranger VII has crossed the seas of space to tell the world things hitherto only guessed about the surface of the Moon."

New York Times—"Ranger VII obtained and transmitted to the earth more detailed information about the Moon than man has ever had before."

"One of the most successful and productive experiments in scientific history."

Philadelphia Inquirer—"A stupendous performance . . . nothing that has gone before can take away from its present and future importance."

Chicago Tribune—"We can all be justly proud of the many scientists and technicians whose skill and care helped make the shot a success."

"This is an amazing achievement."

Washington Daily News—"Seldom has the speed of events in this 20th century age been so dramatized as by America's successful picture-snapping lunar robot."

Los Angeles Herald Examiner—"Moonshot success, amazing photos excel telescopes."

WORLD PRESS REACTION

Reaction overseas to the Ranger VII success was instantaneous. Front-page headlines were written in superlatives. Many front pages carried the early photos of the lunar surface. Here are some samples:

London Daily Mirror—"It's a Hit, Bang on the Moon."

London Evening News—"The First Pictures of the Moon, Even Craters a Foot Deep."

Paris Aurore—"Hurrah for Ranger."

Antwerp Gazet—"Ranger VII Hits Target, Triumph of American Technicians."

Madrid Arriba—"Triumph for the West."

Moscow Radio—"Brilliant" (quoting Soviet Professor Gigran Melkunov)

Tass, Moscow—"Soviet Scientists are happy to note that the launching of Ranger VII is a new national achievement of the United States in its program of exploration of the Moon . . ."

Times of India—"Spectacular."

Uusi Suomi, Finland—"Mystery of Moon Surface Solved."

Frankfurter, Germany, Rundshau—"First Close-Up Photos of the Moon."

Hamburg, Germany, Die Welt—"Americans Succeed in Ranger Experiment—Excellent Photos of the Moon."

Kurier, West Berlin—"Ranger Lands on Moon."

Rome, Italy—". . . a celebration of the development of man's spirit which is the creature of God . . ."—Pope Paul VI.

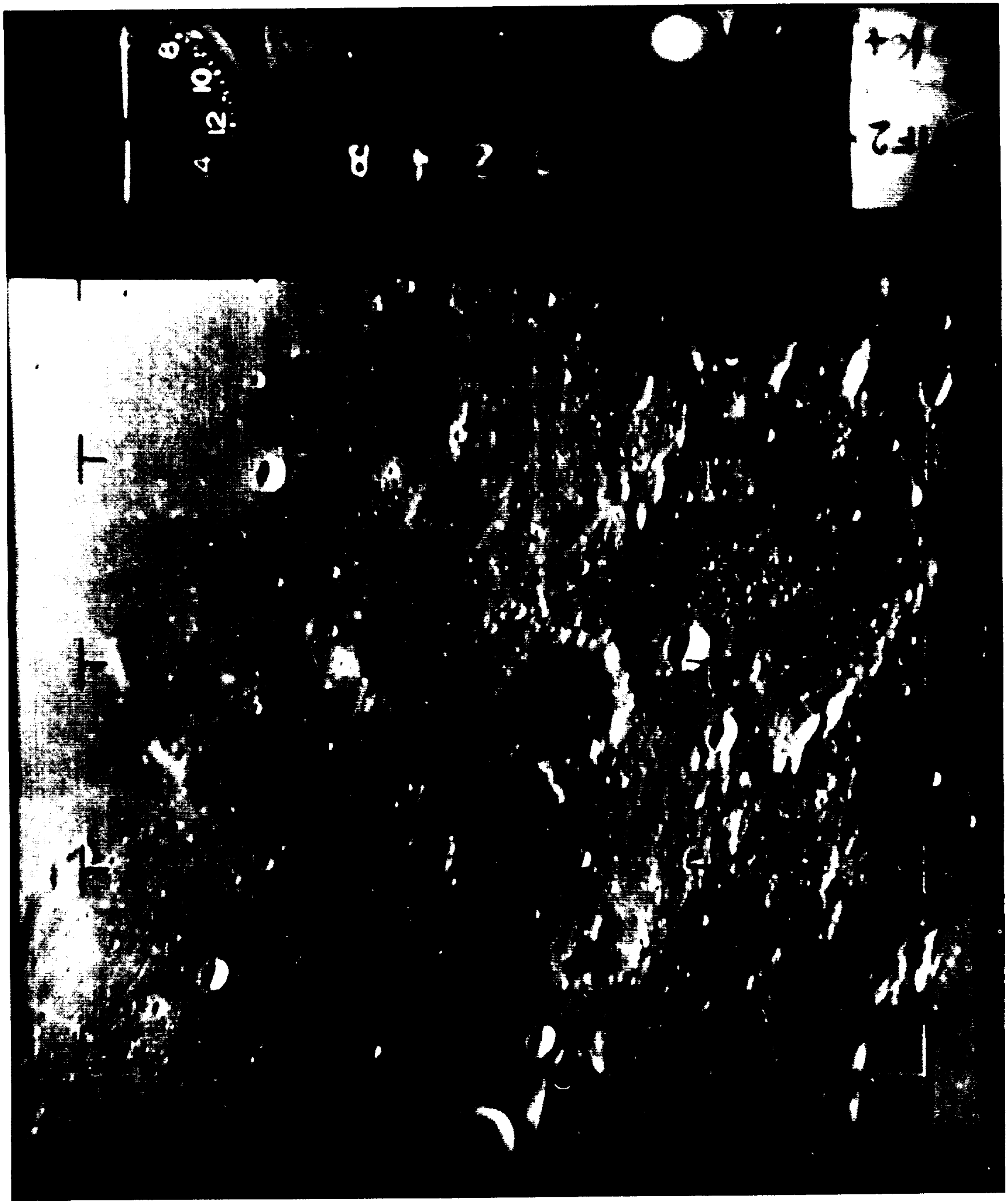

Figure 15 (Frame 248).—Taken from an altitude of 470 miles, this photo shows a lunar surface area about 78 miles on each side. The large crater in upper right is Guericke.

Figure 16 (Frame 317).—Photo showing an area about 113 miles on a side was taken from an altitude of about 235 miles. Eventual impact point of Ranger VII was in the upper right hand portion.

Figure 17 (Frame 359).—From an altitude of 85 miles, Ranger VII photographed this area 48 miles on a side. Craters as small as 500 feet in diameter can be observed.

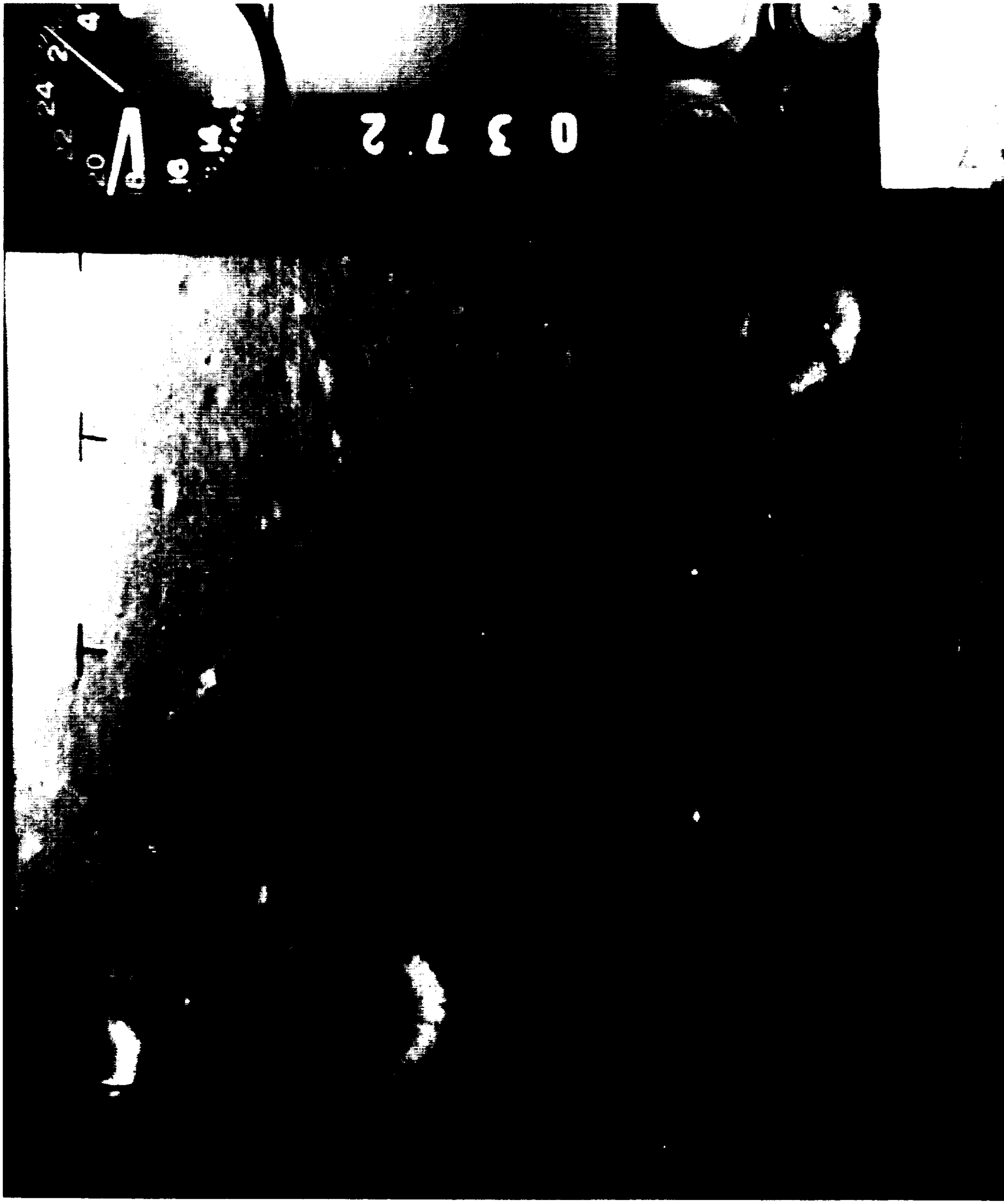

Figure 18 (Frame 372).—At an altitude of 38 miles, this picture shows an area about 4½ miles square. Note ridge extending upward from large crater near bottom center of photo.

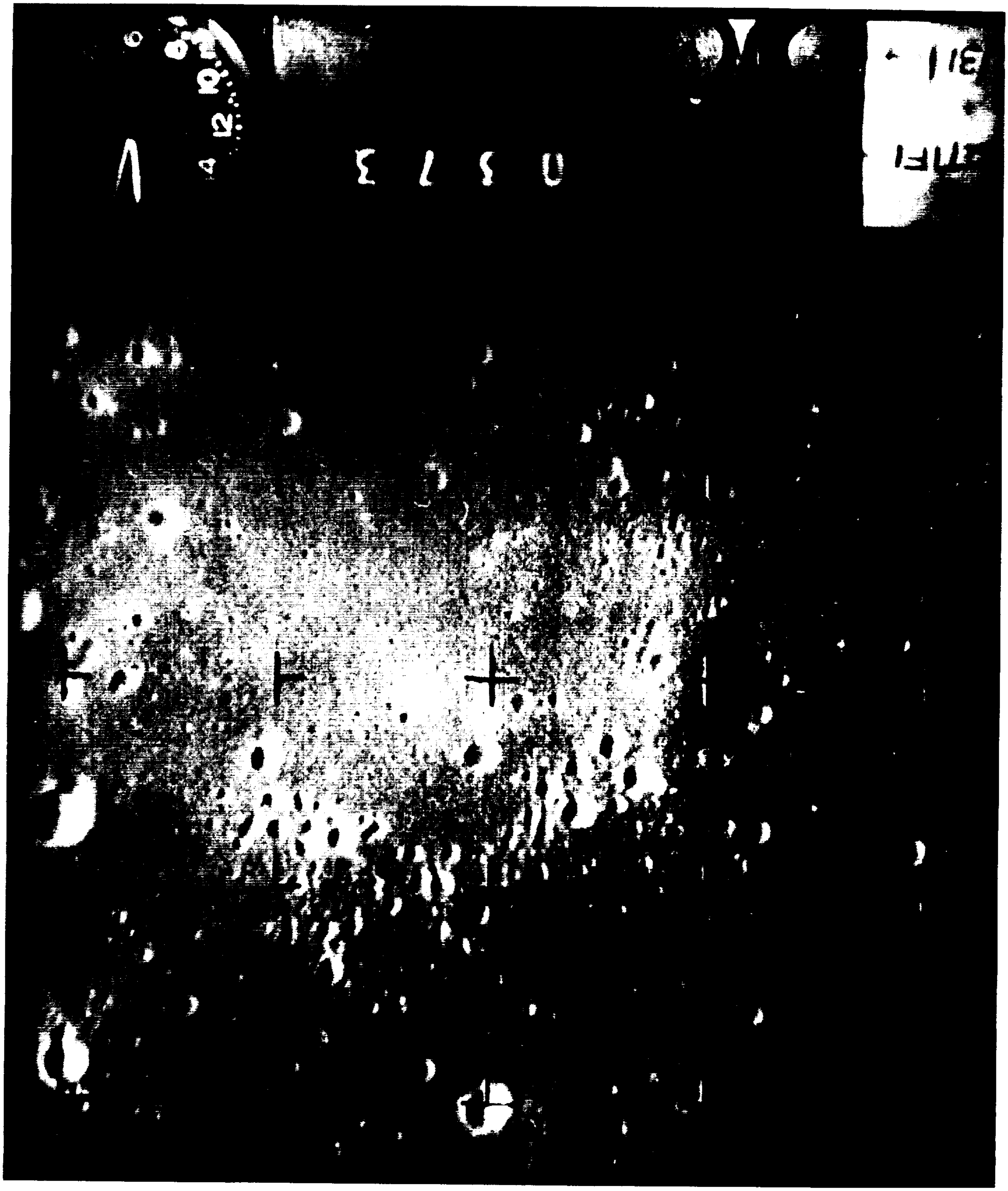

Figure 19 (Frame 373).—This photo of an area of the moon 16 miles square was taken from an altitude of 34 miles by one of the Ranger VII cameras.

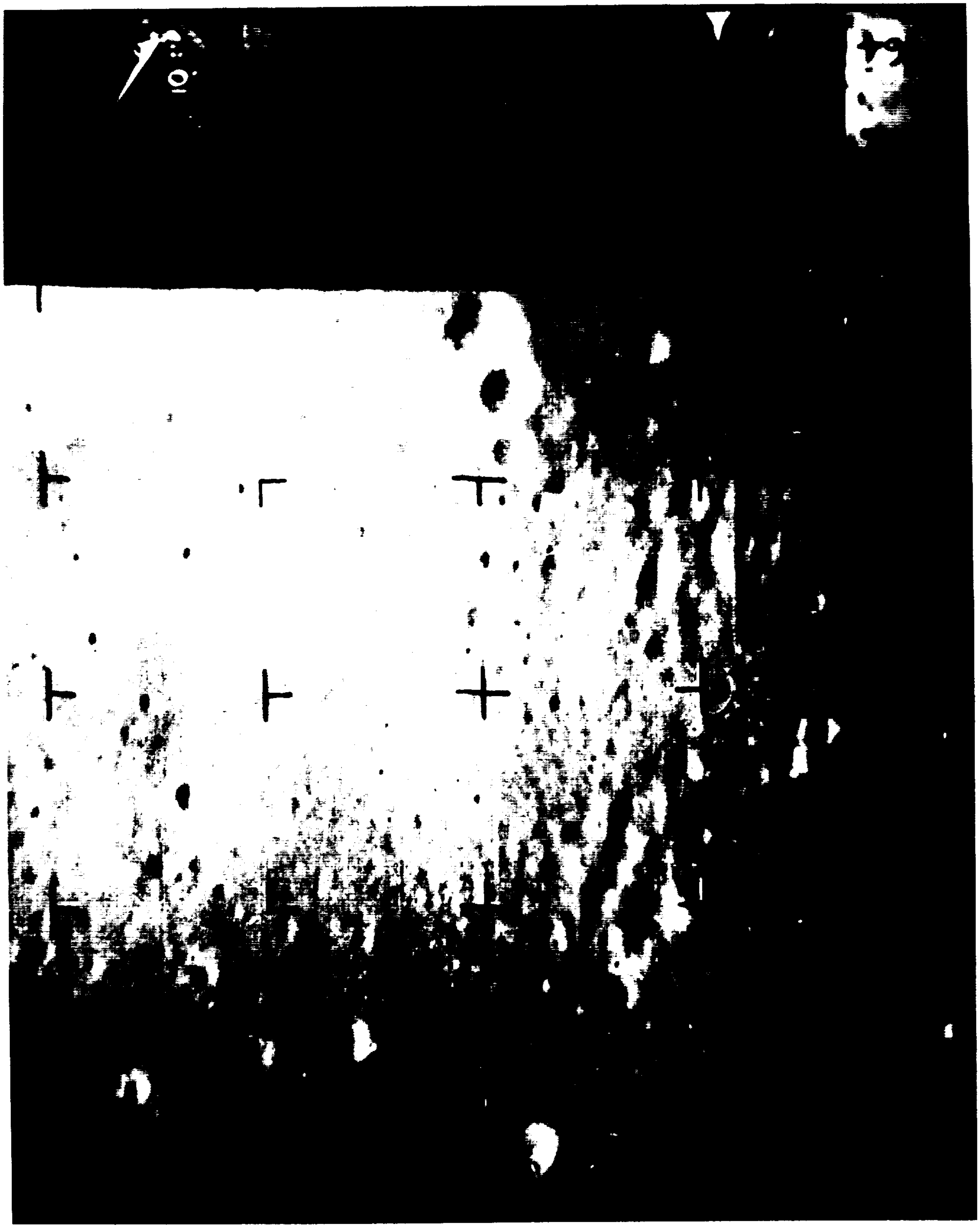

Figure 20. (Frame 379).—An area about 4 miles square is shown in this photo taken from 12 miles above the lunar surface. Note numerous secondary craters with rounded sides.

Figure 21 (Frame 247).—This Ranger VII photograph was taken from an altitude of 480 miles above the moon's surface. Large crater in lower margin is Lubiniezky.

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